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ABSTRACT

A study analyzed think-aloud protocols to investigate and describe what readers who are developing proficiency do as they read. Subjects, three sixth-grade middle-school boys (with grade point averages of 3.0-3.5 on a 4-point scale) from a small West Virginia suburb, read aloud 16 text sections (from one to four sentences in length), thought aloud at the end of each section, and summarized the main points of the text after reading and thinking aloud. The think-aloud protocols were transcribed and segmented into reader-text interactions. Results indicated that: (1) John's predominant interaction with text was elaboration through recall of prior knowledge or experiences; (2) more than half of Curtis' interactions include question or question-related statements; and (3) Ben's verbal reports are quite sparse--all of his responses took the form of one-line statements. Findings suggest that all three subjects demonstrated individual and characteristic patterns of processing within a single text. Findings also suggest that thinking aloud can become an important aspect of learning environments that direct students to attend to the meaning or content of the text without instruction in specific skills by providing a way for both teachers and students to uncover cognitive processes in reading and by providing a context and a vocabulary for a meaningful instructional dialogue about those processes. (Four tables of data are included; 47 references and the think-aloud protocol are attached.) (RS)

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Uncovering Cognitive Processes in Reading

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Introduction

Largely influenced by developments in cognitive psychology, recent reading research has focused attention on the processes of reading. Current models of reading characterize the interaction of readers and text as ongoing constructive activity in which readers connect their prior knowledge and the information they read in a text to create a mental representation that best matches textual information. Readers evaluate this representation, modifying or enhancing it as they read and process new information (Kintsch, 1986). It is the nature of this on-line processing, how and why it occurs, and what it involves, that has become the focus of reading research attention (Beck & Carpenter, 1986).

In an attempt to gain on-line access to the cognitive processing of readers, researchers have turned to thinking aloud as a research tool and have been analyzing think aloud protocols, the transcripts of verbal reports, to gain a deeper understanding of reader-text interactions. In a review of reading research methodology, Afflerbach and Johnston (1984) concentrated on the use of verbal reports, or think aloud protocols, as a method for studying the cognitive processes involved in reading. The classic work explicating the potential problems and presenting the potential benefits of using verbal report data was done by Ericsson and Simon (1980, 1993). Garner (1982, 1987) and Olson, Duffy, and Mack (1984) have also contributed to building a case for using think aloud protocols as a way to investigate on-line reader-text

interactions.

Despite the fact that the research methodology associated with thinking aloud is still being refined and developed and that there are potential limitations, think aloud protocol analysis has become an important tool in literacy research. Flower and Hayes made extensive use of thinking aloud in their study of writing (Flower & Hayes, 1981; Hayes & Flower, 1980, 1983), and a similar line of research has been pursued in reading.

Most reading research involving thinking aloud has been done with proficient readers, generally students in high school or college or adults. This research has contributed to the building of current models that describe the text processing of skilled and fluent readers; however, comparable models do not yet exist for describing how beginning readers and readers developing proficiency interact with text (Juel, 1991; Carpenter & Just, 1986). A survey of reading research involving thinking aloud reveals that more attention is now being directed toward readers who are acquiring proficiency (generally, students in grades four through eight). The sections that follow describe representative studies related to both proficient readers and readers who are developing reading proficiency.

What Do Proficient Readers Do as They Read?

Reading as Problem Solving

Olshavsky's 1976-1977 study was the first in a line of research that looked at reading as a problem solving process making

use of Newell and Simon's (1972) theoretical and methodological frameworks. Olshavsky used the think aloud protocols of her tenth grade subjects to identify the major strategies readers use in comprehending text. She discovered ten unique strategies, ranging from problem identification strategies, such as stating that a word was confusing, to problem solving strategies, such as rereading.

Olshavsky's analysis of her subjects' think aloud protocols revealed that the strategies readers chose to use related to their reading proficiency and to their interest in the text. The strategies also related to the abstract (complex) or concrete (straightforward) nature of the text. Olshavsky discovered that proficient readers used more strategies than less proficient readers; readers with high interest in the text used more strategies than those who were less interested; and readers reading abstract stories used more strategies than those who were reading concrete stories.

Olshavsky's attention to text difficulty and its effects on strategy use was also the focus of more recent work by Caron (1989). Caron analyzed the think aloud protocols produced by undergraduate subjects as they read three expository passages varying in difficulty. Both Caron (with nonfiction) and Olshavsky (with fiction) identified a variety of strategies related to problem solving. Caron's analysis also related subjects' problem solving strategies to their development of a hypothesis about the text, a hypothesis that they seemed to use as a point of reference

as they attempted to clarify their understanding of the text through questioning, predicting, and making inferences.

Reader and Text Variables

Both Olshavsky and Caron manipulated text difficulty in an attempt to discover the kinds of strate es used by readers. Olson, Duffy, and Mack (1984) chose genre and text structure as variables in their investigation of readers' interactions with text. Olson and his colleagues posed the questions: (a) What do readers do as they read a story with a traditional structure? and (b) What do readers do as they read an essay?

The undergraduates who read the stories were asked to make inferences and predictions as well as connect their prior knowledge to text content as they read. Subjects' verbal reports revealed that, as they began to read, subjects were collecting information that they subsequently used to form a hypothesis for what the rest of the story would be about. Once this hypothesis was formed, subjects used it as the basis for making specific predictions about story events.

The undergraduates who read the argumentative essays were asked to comment on the structure of the text as they read. These subjects made predictions about topics in the essay, but their predictions were general in nature.

Olson and his colleagues concluded that readers had distinct orientations toward different genres. While reading stories, readers assumed a prospective orientation, making many specific

predictions. In contrast, while reading essays, readers took a retrospective orientation, or passive stance, making some general predictions but remaining more inclined to suspend their predictions until more information was supplied by the author.

Recent research by Afflerbach (1990) examined this genre-related finding and also investigated the possible influence of readers' prior knowledge on their prediction-making interactions with text. Afflerbach made use of three of the same readings used in the studies by Olson and his colleagues, but he substituted two essays judged to be about topics more familiar to his high school and college subjects.

Afflerbach's findings emphasized the importance of prior knowledge, familiarity with content, as an influence on the frequency of readers' prediction strategies for both stories and essays. Subjects made more predictions with familiar material regardless of the genre.

Further analysis revealed that genre did play a role in readers' prediction-making interactions with text, however. Afflerbach noted that subjects not only used prior knowledge of content but also their knowledge about how texts are organized, specifically how writers organize an argument in an essay, to generate predictions.

A Model of Text Processing

Text processing models developed by Kintsch and van Dijk (cited in Scardamalia & Bereiter, 1984) and Kintsch (1986) relate

to two of the important cognitive processes discussed in the preceding sections. First is the hypothesis formation Olson and his colleagues discovered in subjects who read traditionally structured stories. Hypothesis formation was also referred to by Caron in his study of readers who used problem solving strategies to clarify what seemed to be a hypothesis they had developed about the meaning of the text. Second is the influence of prior knowledge, including knowledge of text structures, on predicting during reading which was described by Afflerbach.

According to Kintsch (1986), constructing meaning from text involves building a representation of the information the text presents. This representation is the result of interactions between the text and the reader's prior knowledge--not only content, or domain, knowledge derived from various experiences, but also knowledge about how texts are organized. These representations are built up, and to some extent torn down and rebuilt, as readers read and process the text.

According to van Dijk (cited in Scardamalia & Bereiter, 1984), the representation constructed from a text that has been comprehended consists of propositions arranged in a hierarchical structure. The highest level in the hierarchy consists of topics or propositions that describe what the text is mostly about. The lowest level, called micro-propositions, is made up of details about the text content. The intermediate level consists of macro-propositions, summaries of major points in the text that involve

thinking about what the text says and how the information relates to what a reader already knows. According to van Dijk, it is at this intermediate level that much of comprehension activity takes place. Kintsch and van Dijk also suggest that creating macro-propositions is a recursive, or cyclical, process involving more than one interaction with the text as readers survey content and reread and check information within the text and compare text information and their prior knowledge.

Scardamalia and Bereiter (1984) believed that a critical difference between expert and novice readers could be found by analyzing protocols to uncover the processing related to summarizing or creating macro-propositions. They set out to investigate this processing in research described in the next section.

What Do Readers Who are Developing Proficiency Do as They Read? Text Processing Strategies

In a study of text processing, Scardamalia and Bereiter (1984) posed two questions: (a) What do novices know about reading, specifically reading strategies? and (b) What strategies do novices use as they read? The studies designed to address these questions made use of the Kintsch and van Dijk text processing models. The subjects for both investigations were 12 sixth graders and 12 tenth graders.

In the first study, subjects read two paragraphs, both of which included anomalous information. The anomaly in the first

passage could be detected by readers who were reading in what might be described as a linear fashion, that is, by readers who were processing the text statement by statement and questioning or relating each statement to their prior knowledge in a sequential manner. In contrast, the anomaly in the second passage could only be recognized by readers who were constructing macro-propositions as they read, that is, by readers who were processing the text in a recursive, or cyclical manner, linking statements from different parts of the text to create an ongoing summary of what the text was describing and relating their knowledge to the information the text presented.

As subjects read each passage, they were asked to think aloud. Statements from the resulting protocols were sorted into two categories: (a) detail interpretations, similar to the micro-propositions described by van Dijk, and (b) macro-interpretations, similar to van Dijk's macro-propositions. Analysis of the statements revealed that there were more detail interpretations than macro-interpretations by both sixth graders and tenth graders. However, tenth graders made four times as many macro-interpretations as sixth graders. The formation of macro-interpretations was correlated to recognition of the anomaly in the second passage, the anomaly that required a cyclical, or recursive, manner of text processing.

The second study involved the same 12 sixth graders and 12 tenth graders who had participated in the first study. This time

their task was to sort two sets of sentences written on strips of paper into coherent texts. One text was a summary of St. Exupery's *The Little Prince*; the other was an expository text about spices in the East Indies. Subjects again thought aloud as they carried out the tasks.

An analysis of the resulting think aloud protocols revealed that sixth graders tended to add one sentence to another with little review of the cumulative text. The tenth graders more often tried out groupings of sentences before settling on a final sequence. The protocols of both sets of subjects were also analyzed for evidence of three types of reading activity: (a) surveying content, (b) rereading and checking, and (c) summarizing. Few sixth graders revised their arrangements based on surveying content or rereading and checking. More importantly, not one sixth grader made use of summarizing. In contrast, the tenth graders consistently made use of all three types of reading activity.

Scardamalia and Bereiter concluded that their findings provided support for the text processing strategies of expert readers described by the Kintsch and van Dijk models. They also emphasized that an important aspect of their work was its focus on the developmental nature of acquiring expertise in text processing by highlighting what novice readers do.

Patterns of Processing

Research by Lytle, Meyers, and their colleagues (1986, 1990) also addressed the question raised by Scardamalia and Bereiter:

What do novice readers do as they read? Lytle's work also addressed how the reader-text interactions that were uncovered might be described so that teachers and students could make use of the information.

In a study done by Lytle (cited in Meyers & Lytle, 1986), think aloud protocols by high school seniors reading nonfiction passages were analyzed for strategies used by subjects when they encountered problems in comprehending the text. The resulting Think-Aloud Protocol Analysis identified discrete responses to text content called moves. The coding system that resulted from the analysis consisted of 21 moves categorized under seven major categories. These major categories and representative moves include: (a) monitoring, such as expressing doubt about the meaning of a word or sentence; (b) signaling understanding, for example, by paraphrasing or summarizing; (c) elaboration, such as connecting personal experiences or prior knowledge to text; (d) reasoning, for example, forming a working hypothesis about the text through predicting, making inferences, and drawing conclusions, and then searching for evidence to confirm or disconfirm it; (e) analysis, or analyzing features of the text such as text structure and word choice; (f) judgment, such as by evaluating appropriateness or importance of ideas in text; and (g) other, no response, verbatim repetition of text, or attempts to decode a word. A complete description of all move categories and associated moves is presented in the appendix.

Lytle used her coding system to analyze the protocols of high school subjects as they read nonfiction passages. Her major finding was that specific moves were consistent for the same reader across texts that varied in length, style, and subject matter. Lytle suggested that an identification of the moves used by individual students could be used as an assessment tool and as the basis for designing specific instructional interventions. This idea was investigated in a case study with a fourth grade student named Caroline (Meyers & Lytle, 1986).

According to both her parents and her teacher, Caroline was not achieving to the level of her ability. To get a picture of Caroline's patterns of moves, she was asked to read a story a little beyond her current reading level and to think aloud after each sentence. An analysis of the resulting think aloud protocols using Lytle's coding system revealed that Caroline used some highly effective moves such as elaborating by using visual imaging and by connecting ideas in the text and signaling understanding by paraphrasing. The analysis also revealed that Caroline did not monitor her difficulties with the text.

As a result of the study, the examiner was able to reinforce Caroline's effective moves and to instruct her in ways to better monitor understanding. By the end of the year, Caroline's general academic performance and scores on standardized tests had improved. Although a single case study involves limitations, the study provided some suggestion of how the Think-Aloud Protocol Analysis

might be used in an assessment-instructional sequence.

Moving beyond a single case study, Meyers and his colleagues (1990) conducted a study with average readers in fourth and fifth grade. The subjects read three narrative passages from published books and then retold the stories. The passages were sufficiently difficult to cause strategic behavior, which as noted earlier had been defined by Lytle as patterns of moves used to solve comprehension problems.

The finding that Lytle reported in her study with high school subjects was again reported for subjects in grades four and five: readers consistently used the same moves across the three different texts. The moves used most frequently were elaboration, signaling understanding, and reasoning. Five subjects were selected from the sample to be more closely investigated in case studies. Data from these five subjects revealed a trend for more successful readers to use a variety of different moves, particularly a high percentage of reasoning moves. Unsuccessful readers tended to rely on one particular move most of the time. Comprehension of the passage as revealed through retelling was significantly and positively related to reasoning moves. Ongoing research by Meyers and his colleagues is designed to secure more information such as this in order to develop process assessment techniques and related instructional models.

Uncovering Cognitive Processes in Reading

The purpose of the present study is to extend the line of

research related to uncovering cognitive processes in reading represented by Scardamalia and Bereiter and Lytle, Meyers, and their colleagues. Specifically, the present study attempts to investigate and describe what readers who are developing proficiency do as they read by analyzing their think aloud protocols using the coding system developed by Lytle and modified by Meyers and Palladino (1989), and to compare the profiles of those readers to the characterization of novice readers suggested by Scardamalia and Bereiter and by Lytle, Meyers, and their colleagues.

Method

Subjects

The readers selected for the present study were three sixth grade boys, Ben, Curtis, and John, from a small West Virginia suburb (population 6,000) made up primarily of families of professionals employed in nearby colleges and businesses.

All three subjects were enrolled in the local middle school which had a total enrollment of 450 students in grades six through eight. All three subjects had grade point averages of 3.0-3.5 on a 4-point scale. One subject, John, was identified as gifted and talented based on a score of more than 130 on the Wechsler Intelligence Scale for Children.

Materials

An excerpt that could stand alone from the published book Almost the Real Thing: Simulation in Your High-Tech World by Gloria

Skurzynski (Bradbury Press, 1991) was the text selected for use because the subject matter seemed to be one that would interest sixth graders and features of the text would require subjects to make inferences. The excerpt consisted of 456 words, 25 sentences, and seven paragraphs. Readability of the text was calculated to be equivalent to a text at the eighth grade level, using the simplified version of the Flesch Reading Ease Formula (Klare, 1984).

The excerpt introduced the concept of simulations by defining them as "imitations of things that exist in the real world" and used the work of the Wright brothers with wind tunnels as an example. The text described how the Wright brothers experimented with different wing shapes, or airfoils, to find the one best suited to flight. This proved difficult to do with gliders on the beach at Kitty Hawk where the wind and weather kept changing, so the Wright brothers tried to conduct their tests indoors at their bicycle shop. They used different airfoils attached to a wheel positioned horizontally on a bicycle and connected to the front bicycle wheel so that it moved when the bike was pedaled. This attempt was not successful either because it was too difficult to keep pumping the pedals at exactly the right speed. To solve this problem, the Wright brothers designed a wind tunnel in which to carry out their experiments. The text concludes by pointing out that the Wright brothers simulated an environment in the wind tunnel, and that today wind tunnel experiments are used with

scaled-down models of planes and spacecraft.

The connection between the Wright brothers' goal (to find an airfoil that would allow aircraft to make the best use of the wind) and their failed and successful attempts to achieve it is not made explicit in the text. The relationship between the Wright brothers' effort and simulations is not explained until the end of the passage. A text concept that is somewhat difficult to describe--the bicycle model with the horizontal wheel--is clearly depicted in a photograph and caption near the related text. A scaled-down model is also shown in a photograph with an accompanying caption near a reference in the text.

The text was divided into 16 sections based on length and content. More than half of the sections consisted of a single sentence. The remaining sections consisted of two sentences and, in one case, four sentences. In the study, subjects read from the book and thus the photographs and captions that accompanied the text were available as well as the book cover and the rest of the book.

Procedures

Each subject took part in a warm-up session which consisted of the investigator identifying the purpose of the study as an attempt to "find out what readers think and do as they read," and explaining that thinking aloud was one way to discover "what goes on inside a reader's head." The investigator then read a paragraph and modeled thinking aloud in two different ways: "easy thinking

aloud," in which superficial associations were given, and "deep thinking aloud," in which meaningful associations and questions were expressed (Chan, Burtis, Scardamalia, & Bereiter, 1992). Following this demonstration, each subject read two paragraphs (about mummies) and was asked to do "deep thinking aloud."

The investigator introduced the text to be read and pointed out the orange marks used to mark off the 16 sections. Subjects were then asked to read aloud until they came to an orange mark and to stop and think aloud at that point.

Before subjects were asked to read, the investigator explained to them that the excerpt they would read involved the Wright brothers and asked them if they had any knowledge of the brothers. John had just completed reading a biography of the Wright brothers, Curtis had been to Kitty Hawk several times and had visited the Smithsonian Institution where he had seen original aircraft used by the Wright brothers, and Ben had done a report on the Wright brothers when he was in the fourth grade.

Subjects were given an opportunity to preview the book and to formulate questions and predictions about its content. Then subjects proceeded to read aloud the 16 text sections and think aloud after each. After reading and thinking aloud, each subject was asked to summarize the main points of the text. All subjects met with the investigator individually, and all interviews were tape recorded.

Data Analysis

The think aloud protocols of Ben, Curtis, and John were transcribed and segmented into reader-text interactions. An interaction was defined as a subject's providing a comment or information related to a specific idea or topic in the text. There were 16 sections in the text subjects read, so each subject would be prompted to provide at least 16 interactions. In some instances, subjects provided more than one interaction per text section. For example, consider John's think aloud protocol for the first text section. The codes that appear in parentheses reveal the boundaries of the reader-text interactions and also show how they were coded using Lytle's coding system, which will be discussed subsequently.

> **Text Section 1:** SIMULATIONS ARE IMITATIONS OF THINGS THAT EXIST IN THE REAL WORLD. ALMOST ANYTHING CAN BE SIMULATED -- IN SOLID MODELS YOU CAN TOUCH, IN SOUND, IN MOTION, OR IN ELEMENTS THAT YOU CAN FEEL, LIKE THE WIND.
>
> **John:** Well I was thinking "simulations," like simulation games on computers (E2)
>
> and um I was thinking of uh of the term "solid materials you can touch" uh I was thinking that uh about the museum I went to and I saw a comet that they had drawn and I touched it and dinosaur bones that they could let you touch and things like that. OK. (E2)

In Lytle's coding system, the code *E2* refers to a reader-text interaction in which a reader connects text information to his or her prior knowledge or experiences. In John's protocol, he connects two different instances of his prior knowledge to two different ideas in the text: the term *simulations* is related to John's knowledge of computer games, and the phrase *solid materials you can touch* is related to John's experiences in a museum with exhibits he was allowed to touch.

Segmenting the protocols into reader-text interactions was the first pass through the data. The second pass involved using the coding system developed by Lytle and modified by Meyers and Palladino (1989) to code each interaction. As noted previously, this system includes seven move categories: monitoring, signaling understanding, elaboration, reasoning, analysis, judgment, and other, as well as specific moves within each category. In the sections that follow, the protocols of each subject are analyzed and discussed. Then comparisons are made between and among subjects.

Results

John. John's protocol reveals that his predominant interaction with the text is elaboration through recall of prior knowledge or experiences. John uses his personal experiences, his reading, and his world knowledge to elaborate the text in 17 of his total 21 interactions. The protocol excerpts that follow reveal that John

connects the text to just about anything he can, from computers and cartoons to trips to the museum and seashore.

- "Well, I was thinking "simulations," like simulation games on computers. . . "
- "I was thinking about the museum I went to. . ."
- "Well, I was thinking of how I used to play with kites [that had] little figures on the top of them . . ."
- "I was thinking of the seacoast when we went. . ."
- "I was thinking how they test cars for aerodynamics."
- "I was watching a cartoon once. . ."
- "I was thinking of the space shuttle. . ."

John's elaborations often include strong visual images, images that he appears to "see" quite clearly, as in the following example.

> "I was thinking about the current again., And how one car they had to push, and they put a ribbon on the top of it, and the ribbon was exactly two inches over it the whole time, and it didn't move or shake."

As the following examples show, John's ability to picture things in his mind seems to contribute to his ability to make meaningful comparisons and to create analogies.

. TEXT: THE AIRFOILS SPUN IN THE BREEZE.

"I was thinking of a helicopter."

. TEXT: INSIDE, A GASOLINE-DRIVEN FAN BLEW...WINDS ACROSS MINIATURE WING MODELS...

"I was thinking how they test cars for aerodynamics. They have this big tunnel and a current blows through."

A connection to information gained through reading a biography of the Wright brothers allowed John to question the plausibility of information in the text that refers to the Wright brothers' failure to pump the pedals of a bicycle at exactly the right speed.

"I was thinking of the bicycle race that they had and how [the pedaling] should be easy because Wilbur had real strong legs and he was good at biking."

John's interactions with text are summarized in Table 1. As the table shows, elaborations such as those described above dominate John's text interactions, accounting for 81% of his total interactions. Monitoring interactions, raising questions or expressing confusion about text content, represent 14% of John's text interactions. A single interaction, representing 5% of the total interactions, involved drawing a conclusion, a reasoning move in Lytle's scheme.

Insert Table 1 here.

Curtis. If John is the elaborator, then Curtis is the reasoner, specifically the questioner. More than half of Curtis's interactions, 61%, include questions/or question-related statements. As characterized by Lytle, searching for evidence to form a hypothesis about the text and self-questioning are characteristic reasoning moves, and Curtis's protocol provides a wealth of examples.

In his interaction with the first text section, Curtis "wonders," and wondering becomes a characteristic response, occurring 14 times. As he reads and encounters new information, Curtis wonders why, he wonders where, he wonders what, and he wonders if. Curtis also asks questions, questions about the text and questions related to his ideas about the text. Often, his self-questioning becomes an extended dialogue with himself in which he tries to figure out what the text means. Curtis's figuring out sometimes involves revising previous ideas and tentatively suggesting new ones that in turn will be evaluated as he continues reading. The protocol excerpt that follows provides an example.

TEXT: WHILE ORVILLE LAY FACEDOWN IN THE CENTER OF A GLIDER'S LOWER WING, WILBUR AND HIS HELPER RAN ALONG THE BEACH, LIFTING THE GLIDER BY THE WINGTIPS UNTIL IT CAUGHT THE BREEZE AND FLEW, LIKE A KITE.

Curtis: "Well, I wonder why they didn't always use the wind. I mean it doesn't sound like they did jump off high areas all the time. Maybe because that was the safest way. Because they weren't sure. So I see that answers my question there. Um. Well, I wonder how they built it so they could, well, you know, it says they lifted the glider with the wingtips, so I wonder did they design the thing so it was strong enough, sturdy enough to do that? Um We'll see."

Almost one-fourth of Curtis's reasoning moves are related to forming a hypothesis about the Wright brothers themselves, who they were, why they did things, and what qualities, abilities, and motivations they had. The protocol excerpts that follow provide examples.

. "I mean like they're psychic or something. I mean how'd they know that already?"

. "Sort of brave to jump off these places in these gliders when they might not even be safe. Might not even fly. Couldn't be sure all the way."

. "Well, hmmm, I wonder like where'd they get the experience

to do this? I mean were they just gifted [and] talented to know all these things?"

"They hadn't been the first ones to do this experiment, but why were they so into it? I mean, why [did] they test over and over again? Seemed like they're desperate, they just had to find out. I mean, wonder if they wanted to reach a goal or a record? I think they just loved flight and just wanted to perfect it. Must be the reason."

Curtis seemed to approach the text ready to grapple with ideas. In the protocol excerpt that follows, he responds to a text section about scaled-down models of airplanes and spacecraft being used in wind tunnels to test conditions that would exist in real flight. He doesn't seem to know if these kinds of tests would really work, and he admits that his concern is difficult to explain, but he continues persistently to articulate his ideas.

"But a scale, uh size sometimes could matter. Like I mean, after a long time of testing these engines and stuff, they could make a certain thing, but it might, it uh, I mean, I don't know if it doesn't always work or not. It might not. Because the scales, the scales, like they don't, they're, they can't be exact. It's hard to explain what I mean. Like say it would be twenty tons and then you took away its size. I mean, could you imagine that that would be it? You'd have

to make the wind blow so that would be the same thing to this as it would be to the twenty ton. Uh, I don't know how I would exactly explain it."

Curtis's interactions with text are summarized in Table 2. The table shows that reasoning moves involving forming hypotheses, questioning, and searching for evidence account for 61% of Curtis's interactions. Elaboration makes up the next largest category of text interactions, 23%. Curtis uses prior knowledge to elaborate text information by adding details. Also included in this category are Curtis's comments about his interest in the text. Curtis's monitoring is related to conflicts he perceives between what he knows or believes and information in the text rather than to doubts about the meaning of specific words or phrases. Monitoring accounts for 12% of his text interactions. Curtis also provides a summary near the end of the excerpt by commenting: "...aerodynamics which I think is mostly what it is," and this accounts for 2% of his interactions.

Insert Table 2 here.

Ben. Compared to the protocols of Curtis and John, Ben's verbal reports are quite sparse. All of his responses take the form of

one-liners such as the following.

. "What the chapter's going to be about?"

. "How they were going to fly?"

. "Which one they were going to pick."

. "How long it was going to stay in flight."

Insert Table 3 here.

As Table 3 shows, 50% of Ben's interactions can be categorized as reasoning moves. These interactions are in the form of predictions and self-questioning such as the following.

TEXT: JUST AFTER THE TWENTIETH CENTURY BEGAN, ORVILLE AND WILBUR WRIGHT PREDICTED THAT PEOPLE COULD FLY.

Ben: Uh how they were going to fly.

TEXT: WHILE ORVILLE LAY FACEDOWN IN THE CENTER OF A GLIDER'S LOWER WING, WILBUR AND HIS HELPER RAN ALONG THE EACH, LIFTING THE GLIDER BY THE WINGTIPS UNTIL IT CAUGHT THE BREEZE AND FLEW LIKE A KITE.

Ben: Uh. Which one they were going to pick.

About 25% of Ben's interactions involve monitoring, in which he expresses doubts related to what the text means and

questions apparent conflicts between his knowledge and text content. At 25% of his total interactions, Ben's percentage of monitoring is much higher than either John's at 14% or Curtis's at 12%. Some examples of Ben's monitoring are given below.

TEXT: BACK AT THEIR BICYCLE SHOP IN DAYTON, OHIO, ORVILLE AND WILBUR TRIED BALANCING A SPIKED WHEEL HORIZONTALLY ABOVE THE FRONT WHEEL OF ONE OF THEIR BIKES.

Ben: What was the meaning of this project?

TEXT: THEN THEY CLAMPED AIRFOIL MODELS TO THE RIM OF THAT EXTRA WHEEL.

Ben: Why they did this?

At one point Ben signals that he agrees with the text section that describes the Wright brothers as being the most knowledgeable about wing shapes as a result of their having tested 200 different airfoils: "That was really true if they did know a lot about these airfoils." Ben's response to the first text section is to characterize it as an overview of what the chapter will be about, an analysis move in Lytle's scheme.

All Three Subjects. Table 4 summarizes the text interactions of the three subjects. Curtis's frequent and extended interactions with the text produced a total of 43 interactions, more than twice as

many as John, who had 21, and almost three times as many as Ben, who had 16, which means that he only responded once per text section. The dominance of a single type of reader-text interaction is evident for all three subjects: for John, 81% elaboration; for Curtis, 61% reasoning; and for Ben, 50% reasoning.

Insert Table 4 here.

One of the findings of this study is that all three subjects demonstrated individual and characteristic patterns of processing within a single text. This is consistent with the results of both Lytle's study (cited in Meyers & Lytle, 1986) with high school seniors and the study by Meyers and his colleagues with fourth and fifth graders which revealed that subjects consistently used the same moves across multiple texts.

Meyers and his colleagues (1990) found that among fourth and fifth graders, the most frequently used move categories were elaboration (34.7%), signaling understanding (29.0%), and reasoning (23.3%). The subjects in the present study did not use signaling understanding moves to any great extent, but elaboration and reasoning were predominant move categories.

In the case study with the fourth grader Caroline reported by Meyers and Lytle (1986), no evidence of monitoring was found in the analysis of her protocol. In the present study, subjects did

provide evidence of monitoring: John, 14%, Curtis 12 %, and Ben 25%.

Lytle hypothesized (cited in Meyers et al., 1990) that readers' strategic behavior could be discovered most readily by examining what they did after monitoring moves. In the present study, none of the subjects demonstrated such strategic behavior. Representative of this finding is the following example. There was one text section, the description of the bicycle experiment, that all three subjects identified as difficult to understand. Yet, as their comments indicate, none tried to resolve the difficulty by engaging in any strategic processing.

TEXT: BACK AT THEIR BICYCLE SHOP IN DAYTON, OHIO, ORVILLE AND WILBUR TRIED BALANCING A SPOKED WHEEL HORIZONTALLY ABOVE THE FRONT WHEEL OF ONE OF THEIR BIKES

- John: "I don't understand why they did that."
- Curtis: "Why would bike people be interested in flight as much?"
- Ben: "What was the meaning of this project?"

After expressing their confusion, not one of the subjects attempted to resolve it. There was no evidence of reasoning or referring to previous or subsequent text information for help in figuring out what the experiment was or what the Wright brothers expected to learn from it.

With few exceptions, the think aloud protocols of John,

Curtis, and Ben all reveal the sequential text processing of novice readers described by Scardamalia and Bereiter. According to Scardamalia and Bereiter, the think aloud protocols of the sixth graders in their study revealed a linear processing of text statement by statement rather than the recursive processing characteristic of the tenth graders who linked statements from different parts of the text as they read, creating an ongoing summary of what the text was describing.

Another source of information in the present study that can be related to subjects' on-line text interactions can be found in the summaries subjects produced after reading. These summaries were created in response to the investigator's request to "tell me what this section of the book was about in a couple of sentences."

In Curtis's summary, he is able to generalize about the text content by combining topical and detail information from the text as well as his prior knowledge. Such processing is similar tc the creating of macro-propositions described by van Dijk (cited in Scardamalia & Bereiter, 1984).

> **Curtis:** "Well, it wasn't all about the Wright brothers, and it wasn't all about aerodynamics. It was just, it was mostly about planes and stuff. Like the Wright brothers goes back, you know, in the history of planes and, um now, in the present, or we're testing planes for the future. It's mostly about aircrafts and stuff, how they are designed

and all the tests [they're] run through and mainly that."

Compared to Curtis, both John and Ben provide much more limited summaries, identifying the major topic of the text (experiments conducted by the Wright brothers) and linking some details to it (flying kites, wind tunnels). This type of processing is similar to Scardamalia and Bereiter's characterization of the processing done by novice readers.

. John: "I'd say it's about the Wright brothers and how they made experiments and how on different kinds of models and how they were trying to go fly on a kite and tried putting an engine on it."

. Ben: "Like what the whole subject was? This was about Orville and Wilbur uh experimenting with wind tunnels and making their first flight, then having two days' experiments of wind tunnels."

Discussion

Applying Lytle's coding system provided an opportunity to evaluate it. In general, assigning a subject's interaction to one of the major move categories devised by Lytle was not difficult to do. Selecting one of the specific moves within a category was more difficult. This observation is supported by the interrater reliability results which were 84% for the assignment of move

categories and 67% for assigning specific moves within categories. The interrater agreement for move categories reported by Meyers and his colleagues (1990) was 83%, a number that they noted "would be substantially higher if reliability had been calculated on the six major categories of moves rather than on the 24 specific moves that were coded" (Meyers et al., 1990, p. 118).

The categories of monitoring, signaling understanding, elaboration, and reasoning were descriptive of the subjects' interactions in the present study. The categories of analysis of text and judging text were not used by subjects.

Although the reasoning category encompasses a variety of interactions, the subjects in the present study did provide evidence of using all those described, including: forming a hypothesis; making a prediction of the sort one would make from a hypothesis; questioning in an attempt to construct meaning; searching for evidence in order to form a hypothesis; explicit use of evidence to confirm or disconfirm hypothesis or prediction, or to answer own question; drawing a conclusion or making inferences; revising prior reasoning move.

Lytle's description of moves in the reasoning, elaborating, and monitoring categories along with the ongoing paraphrasing and summarizing in the signaling understanding category are directly related to the constructive activity emphasized by recent descriptions of reading, to the development of macro-propositions described by van Dijk (cited in Scardamalia & Bereiter, 1984), and

to the behavior of expert readers described by Scardamalia and Bereiter (1984) as well as by Caron (1989), and Olson, Duffy, and Mack (1984).

Lytle's coding scheme was designed not only to analyze protocols but also to make it possible for teachers and students to talk about the information obtained from the analysis. For this purpose, the description of reader-text interactions should be limited to the major move categories. These categories could provide a useful level of specificity for characterizing what readers do and can do to construct meaning from text.

Monitoring, elaborating, and reasoning are particularly descriptive terms that can be used to talk about processing across a variety of domains. For example, writers engage in elaboration while writing or revising by providing details or creating analogies in a manner similar to what readers do as they elaborate while reading. The reasoning processes of forming hypotheses, searching for evidence, and drawing conclusions are relevant not only in reading and writing but in science and social studies as well. Emphasizing the same constructive processes across the curriculum could help in developing a coherent instructional context for students.

A general overview of current approaches in reading instruction suggests that an earlier emphasis on the introduction, practice, and mastery of discrete skills has been replaced by attention to the modeling and transfer of more global strategies.

Most recently, even broader notions for framing reading instruction have been suggested. These include: directing students to attend to the meaning or content of text without instruction in specific comprehension skills or strategies (Carver, 1987; Pearson, Roehler, Dole, & Duffy, 1992); focusing on broad notions of constructive activity such as assimilation, problem solving, and extrapolation (Chan, Burtis, Scardamalia, & Bereiter, 1992); negotiating meaning by setting up a kind of dialogue with an author (McKeown, Beck, & Worthy, 1993); and cognitive process instruction involving flexible use of a variety of strategies for understanding and interpreting a particular text (Pressley et al., 1992; Gaskins, Anderson, Pressley, Cunicelli, & Satlow, 1993).

An important aspect of implementing and evaluating these new instructional approaches is considering whether or not they provide opportunities for sharing the kind of information about reading that will be most useful to readers developing proficiency. If, as the present study and related studies suggest, novice readers have individual text processing patterns, then those should be addressed in some way. Providing a learning environment that supports and encourages sharing of individual approaches to meaning-making should also be considered. Thinking aloud could become an important aspect of such learning environments by providing a way for both teachers and students to uncover cognitive processes in reading and by providing a context and a vocabulary for a meaningful instructional dialogue about those processes.

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Appendix

Think Aloud Protocol Analysis:

Moves and Move Categories Used by Readers

(derived from Lytle, Meyers & Palladino, 1989)

M	**Monitoring of Doubts**
M1	Statement or question indicating reader's awareness of failure to understand or of only partial understanding
M2	Statement or question relating to conflicts within the text or between text and reader's knowledge or beliefs
S	**Signaling Understanding**
S1	Statement of agreement or understanding
S2	Paraphrase
S2i	Incorrect paraphrase
S3	Summary of information from at least three sentences
E	**Elaborating the Text**
E1	Use of sensory imagery, visual, auditory, or kinesthetic
E2	Recall of prior knowledge or experiences revealed through reference to specific anecdote, person, book, or experience; or recognition that prior knowledge is lacking
E3	Reference to ideas stated previously in the text, noting connections between earlier idea and current text
E3i	Reference to reader's previous ideas related to text
E4	Elaboration or expansion by addition of details
E5	Personal response to text in terms of interest, like or dislike, or emotional reaction to text or to think aloud task

Appendix continued

R **Reasoning**

R1 Formation of hypothesis or working assumption, including hypothesis about writer's position

R2 Prediction about what is to follow

R3 Search for evidence; self-questioning in attempt to construct meaning; indication that reader is searching for evidence to form hypothesis through remarks about reading, rereading, or using context

R4 Use of evidence in text to confirm or disconfirm hypothesis or prediction, or to answer own question; conclusion, inference

R5 Revision of prior reasoning move

A **Analyzing Text Features**

A1 Remarks about text in terms of author's word choice, impact of specific words

A2 Remarks about text in terms of sentence length, punctuation, grammar, and their effects on understanding

A3 Remarks about text structure, functions of sentences or paragraphs in text in relation to other parts of the text

A4 Remarks about rhetorical aspects of text such as tone, genre, use of figurative language; also comments about author's including or excluding important information

Appendix continued

J	**Judging the Text**
J1	Evaluation as opposed to personal response to text in terms of appropriateness, effectiveness, difficulty, or importance of sentences or ideas
J2	Evaluation as opposed to personal response to text in terms of text structure, word choice, sentence length, punctuation, grammar
O	**Other**
O1	Refusal or no response
O2	Word for word paraphrase
O3	Decoding
O4	Skipped text

Table 1

John's Interactions with Text

Move Category/ Move	Number of Occurrences	Percentage of Total Number of Occurrences
Monitoring	3	14%
Elaboration	17	81%
Reasoning	1	5%

Table 2

Curtis's Interactions with Text

Move Category/ Move	Number of Occurrences	Percentage of Total Number of Occurrences
Monitoring	5	12%
Signaling Understanding	1	2%
Elaboration	10	23%
Reasoning	26	61%
Other	1	2%

Table 3

Ben's Interactions with Text

Move Category/ Move	Number of Occurrences	Percentage of Total Number of Occurrences
Monitoring	4	25%
Signaling Understanding	1	6%
Reasoning	8	50%
Analysis of Text	1	6%
Other	2	13%

Table 4

Summary of Subjects' Interactions with Text

	John	Curtis	Ben
Total Number of Interactions	21	43	16
Percentage of Total Number of Interactions in Move Categories			
Monitoring	14%	12%	25%
Signaling Understanding	--	2%	6%
Elaboration	81%	23%	--
Reasoning	5%	61%	50%
Analysis	--	--	6%
Other	--	2%	13%